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Industrial Recycling of Technogenic Wastes and Mineral Ore Processing

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Abstract. Drop damage resistance is experimentally found and breaking stress is determined in radial compression tests for green and dry chrome concentrate briquettes. The paper studies the influence of compaction pressure and the amount of the binder on compactibility in the testing of cylindrical briquettes. The aim of the study is to determine optimal briquetting process conditions for the production of high-quality metallurgical briquettes by roll briquetting.

INTRODUCTION

Since 1991 the “Spidermash” JSC and the Ural Federal University, together with the Institute of Engineering Science, have developed theoretical bases for processing waste compaction; briquette and pellet production technologies, including roll briquetting and stamping briquetting; import-substituting technologies and industrial equipment for technogenic waste recycling and raw materials processing [1 – 5]. The team authoring this paper has published 3 monographs, over 30 articles in Russian and international journals. The briquetting technology and design of roller presses are covered by Russian Federation patents (RU 146458, 2306226, 2197389, 2116201, 2093364, 2100204).

Experimental studies on the recycling of the metallurgical waste and ore screening are made, including the following materials: dust and slime of ferrous and nonferrous metallurgy; mill scale; metal shavings (including cast iron, aluminum and copper shavings); concentrates and tailings of ferrous and nonferrous ores; limestone, dolomite and magnesia dust; dust and slime from coal, coke and by-product processes; fertilizers, pharmaceutical products, aluminum fluoride, cryolite, nickel-containing raw materials; blast furnace sludge and dusts from gas cleaning systems etc.

Equipment for technogenic waste processing lines has been developed, which includes the following: roll briquetting presses, compactors, bins, dosers and conveyers. Serial production of roll briquetting presses has been developed, with a production rate of 2 to 50 ton per hour.

In order to implement import substitution and a more efficient use of waste from the metallurgical and mechanical engineering industries, it is proposed to use serial roll presses manufactured by the "Spidermash" JSC (fig. 1, a) instead of Ludman roll presses, USA (installed, for example, at the Ural Mining and Metallurgical Company), presses produced by the Ekoenergia enterprise, Ukraine, Chinese roll presses and others.

The paper discusses technological aspects of chrome concentrate briquetting in processes depending on the charge composition and compression pressure.

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EXPERIMENTAL PROCEDURE

Materials

The chemical composition and screen analysis of beneficiated chrome ores and recyclable metallurgical dusts from gas cleaning are given in Table 1 and Table 2. The chrome concentrate from the Donskoy GOK (TNC Kazchrom JSC, Kazakhstan) was briquetted in the Briquetting Laboratory of the Spidermash JSC.

TABLE 1. The chemical composition of chrome concentrate and recyclable metallurgical dust from gas cleaning

Components	Component Percentage of Chrome Concentrate, %	Component Percentage of Recyclable Metallurgical Dusts, %
Cr_2O_3	53.50	21.70
SiO_2	6.24	15.77
CaO	0.12	0.90
MgO	19.23	35.20
Al_2O_3	8.20	8.17
FeO	11.46	7.47
S	0.013	0.91
C	-	4.83
loss on ignition	1.80	4.43

TABLE 2. The screen analysis of chrome concentrate and recyclable metallurgical dust from gas cleaning

Fraction Size, mm	Percentage of Chrome Concentrate, %	Percentage of Recyclable Metallurgical Dusts, %
+ 1 mm	9.69	-
- 4 + 1 mm	-	98.00
- 1 + 0.4 mm	14.76	-
- 0.4 + 0.2 mm	23.49	-
- 0.2 + 0.063 mm	33.51	-
+ 0.063 mm	18.55	-

Preparation of Samples

Preparation of samples for the briquetting process was carried out by mixing of chrome concentrate with different amounts of metallurgical dust from gas cleaning and the binder (liquid glass). Compaction was performed on an EDZ-20 universal testing machine. Briquettes were pressed at a speed of 0.2 m/min. The chrome concentrate was compacted in a cylindrical die with the inner diameter of 45.8 mm (with the cross-section of 1647.5 mm^2). The briquettes weighed 40 ÷ 50 g.

The apparent, current and green densities of the briquettes were determined by the die dimensions and the standard method of determining densities. The produced briquettes were subjected to drop damage resistance testing and radial compression testing (the so-called Brazilian test). Green and dried cylindrical briquettes were tested. The dried briquettes were produced by air drying for 24 hours at room temperature.

In drop damage resistance testing, 4 briquettes were individually dropped from a height of 2 m onto a steel plate. The drop damage resistance of the briquettes was determined as the percentage ratio of the briquette fraction weight +5 mm to the initial briquette weight. The mean value for the tested briquettes gives their average dropping damage resistance.

In testing for radial compression of briquettes between parallel steel plates to breaking, the average breaking stress was determined on 3 briquettes. The obtained values offer the average breaking stress.

In experiments on chrome concentrate compaction, the following parameters were varied: the compaction pressure equal to 25 ÷ 200 MPa; the binder content (liquid glass) in the charge material equal to 0 ÷ 5 %; the moisture content in the charge material equal to 2 ÷ 8 %; the gas cleaning dust content in the briquettes equal to 0 ÷ 40 %.

RESULTS AND DISCUSSION

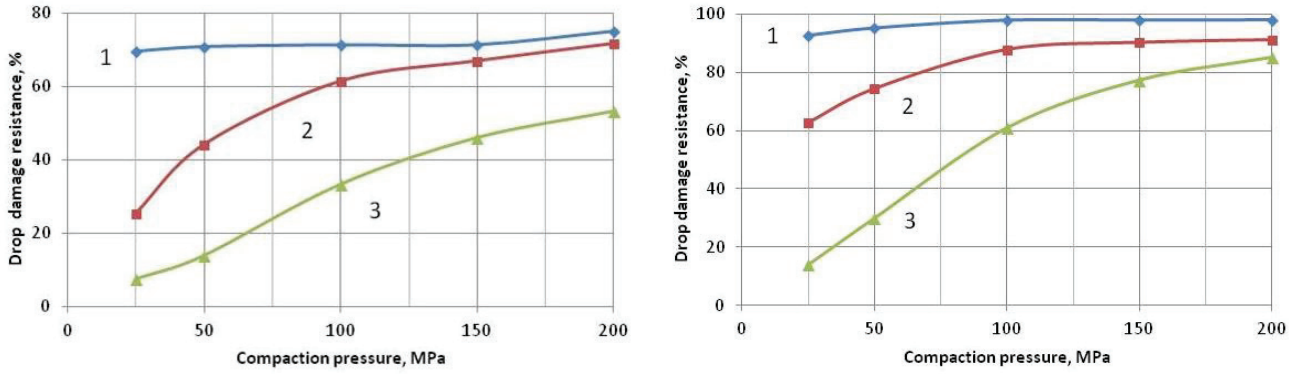
A large number of experimental data has been obtained within the study. The green density of the chrome concentrate briquettes as dependent on compaction pressure is shown in fig. 1 (b).

The drop damage resistance for green and dried briquettes, with the liquid glass content in the charge material equal to 3% and the initial moisture content equal to 2%, is shown in fig. 2.

The breaking stress of the dried briquettes as dependent on compaction pressure is shown in fig. 3.

(a) (b)

FIGURE 1. A roll press manufactured by the Spidermash JSC, Russia (a), and the green density of briquettes with the liquid glass content equal to 3% (b) for the initial moisture content of 2% (1), 4% (2) and 6% (3)



(a) (b)

FIGURE 2. The drop damage resistance as dependent on compaction pressure for green (a) and dried (b) briquettes. The liquid glass content in the charge material is 3% and the content of gas cleaning dust is 0% (1), 5% (2) and 15% (3). The initial moisture content in the charge material is 2%

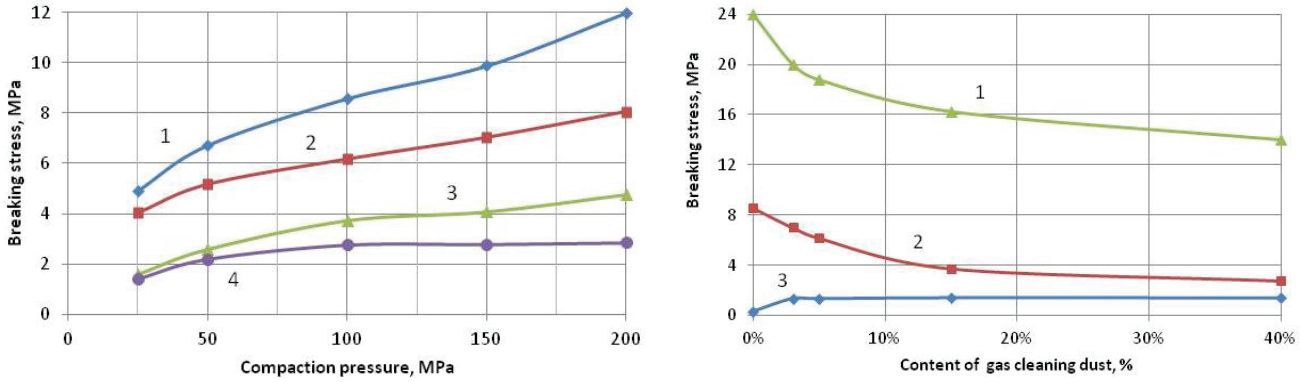


FIGURE 3. The breaking stress of the briquettes in radial compression tests (a) as dependent on compaction pressure (the liquid glass content is 3% and the initial moisture content is 2%, with the content of gas cleaning dust equal to 0% (1), 5% (2) 15% (3) and 40% (4)) and the breaking stress (b) as dependent on the content of gas cleaning dust for the liquid glass content equal to 5% (1), 3% (2) and 0% (3)

CONCLUSION

The main aim of the study is to determine the optimal conditions for chrome concentrate briquetting. The analysis of the experimental results has allowed the optimal briquetting conditions to be determined. The following is recommended:

- use the optimized content of the binder (liquid glass) in the charge material equal to 3 ÷ 5 %;
- use the optimized initial moisture content in the charge material equal to 2 ÷ 4 %
- use the optimized compaction pressure equal to 100 ÷ 150 MPa.

For industrial briquetting of chrome concentrate, the cell shape produced by a press roll has been found; namely, the cell length is 50 mm; the cell width is 46.5mm; the cell depth is 12mm; the cell volume is 32 ÷ 40 cm^3; the briquette weight is 90 ÷ 120 g.

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